Utilization of a Ducted Wind Turbine in a Trailer Mounted Renewable Energy Micro-grid (TREM)

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TREM System for CERDEC
Goal of TREM

• First unit delivered to CERDEC in fall of 2010

• Focused on creating a 2 to 5kW system maximizing the wind resource

• Energy storage to eliminate renewable energy variability

• Customizable to maximize renewable resource at a given location
Overview of Initial System

• A mobile renewable power system platform utilizing a 4.5BT-500 Turbine as primary power source.

• First generation system leveraged commercial off the shelf components in conjunction with some required custom designed components which will allow for an efficient and economical initial solution.

• The target design of the system solution will be to provide a platform capable of accepting a wide range of voltages and therefore greater options with regards to power generation sources.
Trailer Components

• Power creation
  • Ducted Turbine
  • Solar PV
  • Generator / Grid

• Energy Storage
  • Initial Unit with 14kWh of VRLA

• Power Distribution
  • Multiple AC and DC outputs and voltages
WindTamer Ducted Turbine
VIDEO

• To be included on CD at show
Patented Design

Patent: Fluid Driver Vacuum Enhanced Generator

- Design uses the wind to induce rotation just as conventional wind mills

- Utilizes a sophisticated bypass system that harnesses one vacuum that forms internally behind the blades

- Second vacuum that forms externally to assist rotation
4.5GT AEO

- **Typical Open Rotor (8 ft diameter)**
- **AEO for 5.4GT (kWh)**
Advantages of Ducted Turbines

• Low Noise Operation

• Minimal maintenance – 2 moving parts

• Safety – No open spinning blades
  • There is no danger of blade throw or ice build up

• Enhanced efficiency of available wind power over open rotor systems

• Real-time monitoring and braking to insure system safety and maximum energy generation
Solar PV

- Wind and Solar are an excellent compliment
- Configurable to energy creation scaling
- Initial system utilized thin film solar PV
- More recent systems incorporate ruggedized monocrystalline panels for maximum efficiency.
Energy Storage and Power Distribution

- 16 Batteries PowerSonic VLRA: 14.2kWh total storage
- Designed Capacity of 7.2kWh: Limit VRLA to 50% to maximize cycle life
- Maximum AC Discharge of 2kW
- Maximum DC Discharge of 600W
## Input Power

<table>
<thead>
<tr>
<th>Source</th>
<th>Voltage</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Turbine</td>
<td>Variable: 0 to 55VDC</td>
<td>.40-.45 efficiency from available wind</td>
</tr>
<tr>
<td>Solar Panel</td>
<td>15VDC, 110 Watt</td>
<td>85%, 6hrs optimal light</td>
</tr>
<tr>
<td>AC</td>
<td>Shore Power (AC direct from utility source of generator)</td>
<td>120 VAC</td>
</tr>
</tbody>
</table>
## Output power

<table>
<thead>
<tr>
<th>Power Type</th>
<th>Max Power Rating</th>
<th>Current Rating</th>
<th>Connection Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 VAC</td>
<td>2000 watts</td>
<td>30 amps (2 15A breakers)</td>
<td>4 GFI outlets</td>
</tr>
<tr>
<td>12 VDC</td>
<td>300 watts (100 W ea. outlet)</td>
<td>10 amps each connector</td>
<td>3 Cig style outlets</td>
</tr>
<tr>
<td>28 VDC</td>
<td>300 watts</td>
<td>30 amps (fuse)</td>
<td>4 pin weather proof connector</td>
</tr>
</tbody>
</table>
Mechanical Overview

• System Mounted to 6'8" x 14' tandem axle trailer
  • Tube rail, wood deck, jack with autoleveling
• Custom and Pre-Fab Cabinets vented for battery, electronics and additional storage
• COTS Winch System
• Weight Distribution Balanced for towing and stability
• Interface Controls
  • Favor Driver side of trailer
  • Basic gauging + monitoring
Unit Validation

Charge Time based on Wind Speed (need 7kWh to charge 50% depleted battery)

<table>
<thead>
<tr>
<th>Wind Speed (mph)</th>
<th>Solar (6 hr Radiation)</th>
<th>Wind Output 24 Hours</th>
<th>Recharge Time from only renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>75W/h</td>
<td>75W/h</td>
<td>81 hrs</td>
</tr>
<tr>
<td>16</td>
<td>75W/h</td>
<td>200W/h</td>
<td>30 hrs</td>
</tr>
<tr>
<td>20</td>
<td>75W/h</td>
<td>400W/h</td>
<td>16 hrs</td>
</tr>
<tr>
<td>24</td>
<td>75W/h</td>
<td>600W/h</td>
<td>11 hrs</td>
</tr>
<tr>
<td>28</td>
<td>75W/h</td>
<td>800W/h</td>
<td>8 hrs</td>
</tr>
</tbody>
</table>

Testing of unit continues at Aberdeen Proving Grounds
Usage Savings versus Generator and JP8

- No requirements to provide logistic fuels (renewable energy)
  - Fewer people delivering fuel (cost and safety)
- 10kW Generator Uses 10 to 15 gallons of JP8 per day
- At $15 per gallon annual savings of $121,667 in JP8 alone
Future Iterations / Learning from Initial Build and Testing
Revised System Architecture
Energy Generation

• Wind Turbine
  • 5.4BT-500
  • Multiple micro-turbines 300 to 500 watts
  • Increase efficiency reduce duct size and weight

• Solar PV
  • Rapid deployable / ruggedized 230W to 250W panels

• Fuel Cell
  • Smart Fuel Cell EVOY PRO 2200 XT
Energy Storage /Power Distribution

- Chemistry Agnostic based on system requirements
  - Lithium Ion, Lead-Acid and NiMH
  - Based on application requirement
    - Temperature
    - Cycle Life
    - Cost
    - Weight
- Power Distribution from 1kW to 1MW
- Scalable from Mobile Unit to Commercial Building
Mechanical / User Interface

• Ruggedization for each environment / applications
• Telescoping pole for various turbine heights
• Integration of remote monitoring capabilities
• Various Deployment Versions:
  • Permanent off trailer with parallel capabilities for larger installation
  • Rapid Deployment
  • Semi-mobile with larger solar array
Thank You